RISK ORIENTED REHABILITATION STRATEGY BASED IN MEASURED CCP-VALUES

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The quality of the German infrastructure has compared to other industrial countries a high level. According to a study of the world economic forum [1] only the city states of Hong Kong and Singapore have a better ranking. These infrastructure networks were built up over several decades in the past and have to be rehabilitated to fulfil the basic requirements for a high competitiveness for the future.

Age structure – technical lifetime expectancy

An aging process for infrastructure networks is more or less influenced by external factors. According to the age structure and the knowledge about these influencing factors a rehabilitation rate in the future can be calculated. Precise data about these factors will lead to a higher accuracy of the described aging process which is connected to necessary financial resources.

For calculating the rehabilitation rate several methods can be used started by a rough estimation up to a detailed company-specific approach. With an example of urban low pressure steel-pipe network theses several methods are explained.

In the German regulation for grid fees for the access to gas networks [2] normal operating life times for pipes are defined in appendix A chapter 5. The German guideline G 401 [3] offers also normal lifetime expectancies for pipes. In this guideline the possible time span for the operating life is much higher. The mentioned operating life times are listed in table 1.

GasNEV [2]	DVGW G 401 [3]
Steel Bitumen coating = 45-5 5a Steel PE coating = 45-55 a	Steel Bitumen/Textile coating = 50-100 a Steel PE coating= 50-110 a

Table 1: example of normal operating life times

The easiest method of calculating a rehabilitation need for the future is to refer the normal operating life time to the construction years of the pipes. If the normal operating life time is reached the pies have to be renewed. For the described example about 12% of the pipes have an age over 50 years and should therefore be renewed (Figure 1).

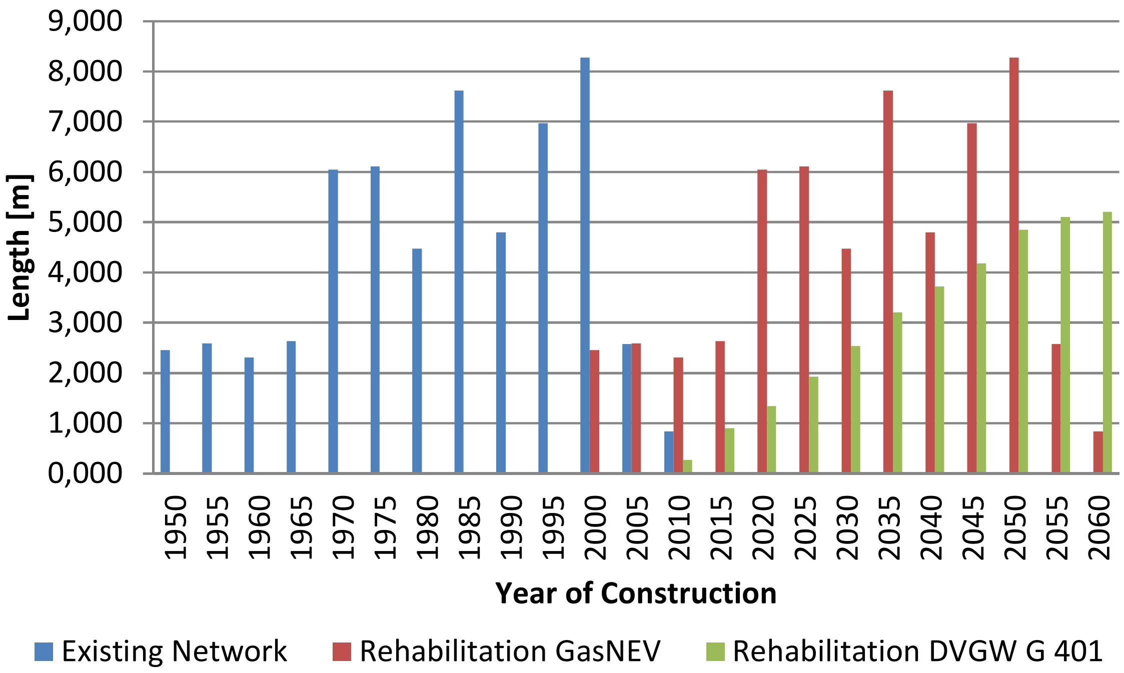

Figure 1: rehabilitation need regarding the normal operating life time

Another method is to use a fitted aging function (e.g. Herz-function) for the time span for a normal operating life time according to DVGW G 401 (old) and refer this hazard rate to the construction years. With the assumption that the highest probability of reaching a life time is in the middle of the time span the rehabilitation need will be more smooth (Figure 1). According to the longer life time the rehabilitation need will be spread of a longer period. Both methods are standardized assumptions and are not connected to company specific situations.

Failure Statistics

For a more detailed prediction of an investment need in the future the company specific experience should be included. As gas pipes are an underground infrastructure the condition of pipes without CCP (cathodic corrosion protection) can be defined by a failure statistic or by excavation. In the left side of Figure 2 for recorded failures a hazard function was fitted to the data. Therefore the company specific situation is better represented. A pessimistic and an optimistic approach were used to take the accuracy of failure data into account.

With the connection between an age depending hazard rate and the actual construction years a rehabilitation rate for the next years can be calculated. For the presented example the rehabilitation need is about 1,100m per year.

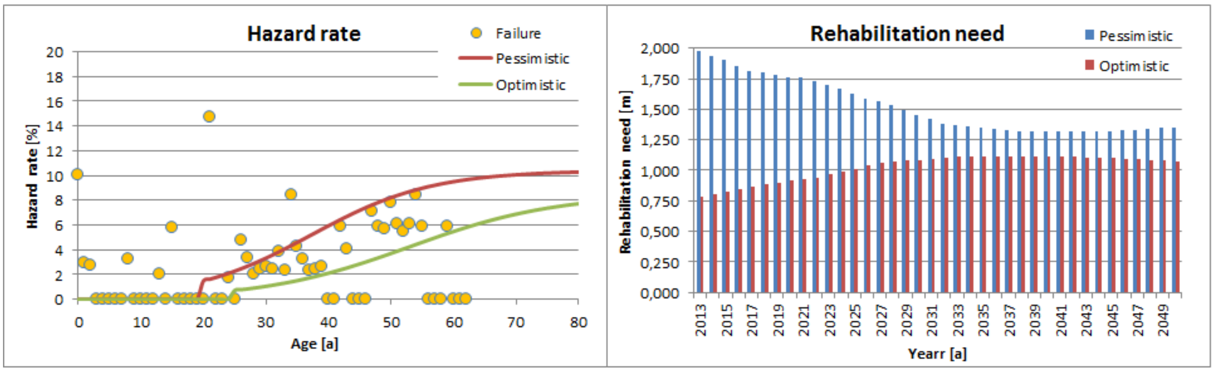

Figure 2: fitted hazard rate and rehabilitation need

Condition evaluation based on ccp-values

The methods described in the previous chapters can be used if the condition of underground pipes has to be estimated over a failure statistic. For steel pipes condition based analysis is possible by using a cathodic corrosion protection system (CCP). Periodically measured CCP-values reflect the condition of the coating and also the effectiveness of the CCP in all major defective zones according to DIN EN 12954 (2001). In the German guideline DVGW GW 18 [4] the advantages of a condition evaluation with CCP-values are mentioned. With the additional information the condition can described with a higher accuracy which can lead to a better usage of the life time.

The main attributes for a condition evaluation are the effectiveness of the CCP according to DVGW GW 10 [5] as well as the specific coating resistance and the current density of each monitoring area or monitoring segment. With further attributes like the influence of AC voltage or the time without full effectiveness of CCP will lead to an ongoing improvement of the condition evaluation. Another advantage is the use of remote control. With a remote control unit according to DVGW GW 16 category 2b [6] a daily the check of the effectiveness of the CCP for the whole monitoring area is possible. A time dependency of the condition of the coating and a possible trend for the future is possible if the metered values are pictured over a longer period. In Figure 3 the ongoing deterioration of the coating is pictured.

In the following example the condition evaluation according to DVGW GW 18 appendix A was used where the mean current density is measured as well as the effectiveness of the CCP is proved. In Table 2 the indicators are used to calculate a condition between 1 (best) and 5 (worse).

Year (-)	Ip (mA)	Length (m)	Surface (m²)	Jp (µA/m²)	Indicator (Is)	Protection criteria fulfilled	Evaluation (1-5)
2005	1190	11,057	7,156	166.3	16.6	yes	2
2006	2619	11,057	7,156	366.0	36.6	yes	2
2007	3571	11,057	7,156	499.0	49.9	yes	3
2008	4905	11,057	7,156	685.5	68.5	yes	4
2009	5476	11,057	7,156	765.3	76.5	yes	4

Table 2: CCP-values for a monitoring area

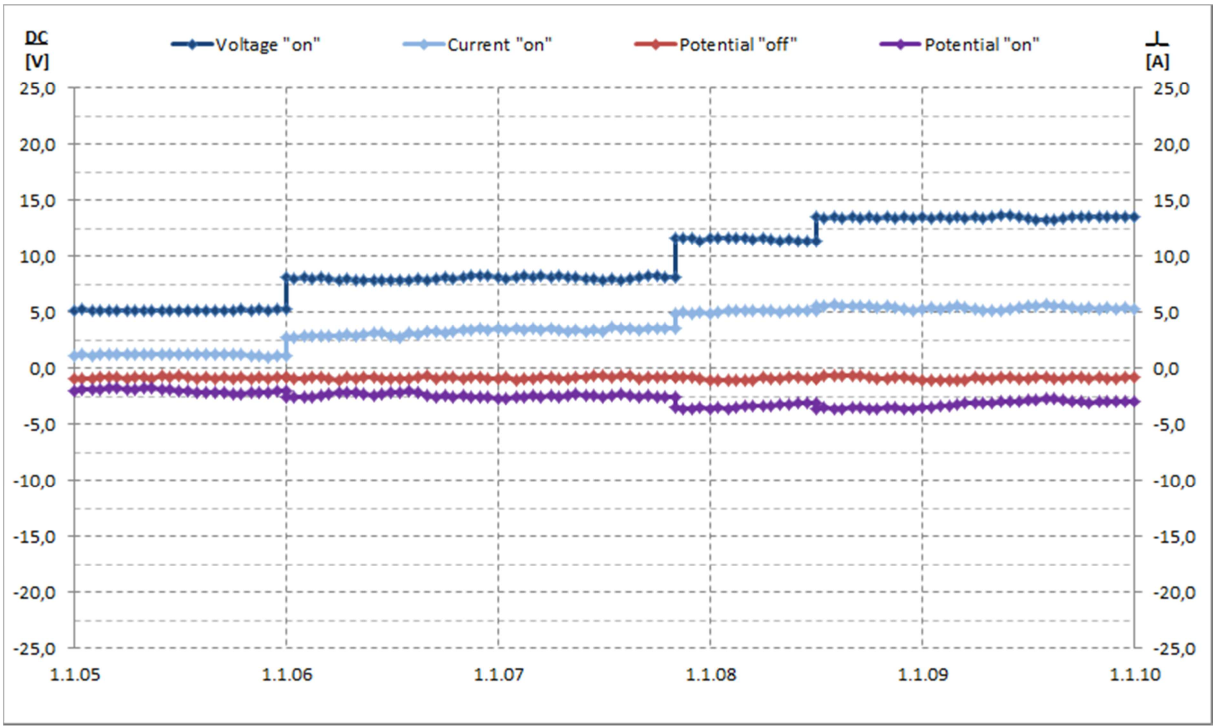

Figure 3: chronological sequence of CCP-values in a monitoring area

With the time dependency of the metered values a prognosis for the expected condition of the coating in the future for a monitoring area is possible. Therefore an estimation of a required budget for repairing of failures at the coating or renewal of a complete pipe segment is possible.

The implementation of an online-monitoring as a permanent monitoring with a very high sampling rate of the main CCP-attributes by remote control will lead to a higher accuracy of condition evaluation. A monitoring concept according to DVGW GW 2c is possible with this method. With the sensitivity of these systems also a small change in the coating of the systems caused for example by an external event can be measured. So these systems can be used also as an alert system.

According to the experience of the author next to the CCP-Values also additional information to the pipeline should be used for a condition analysis. Attributes like the influence of streets, the distance to buildings, the age and therefore the probability of a failure, the importance and therefore the influence of the supply guarantee or the quantity of critical components shall be used. With the information of these attributes the condition evaluation according to DVGW GW 18 appendix D is possible (Equation 1).

Equation 1

BWZ = (VersW + KKSBWZ + AkrB) * (1 + FStr/10 + Risk/10)

BWZ = Bewertungszahl (= condition indicator)
VersW = Versagenswahrscheinlichkeit (= failure probability)

KKSBWZ = KKS-Bewertungszahl (= CCP-condition indicator)
AkrB = Anzahl kritischer Bauteile (= number of critical components)
FStr = Straßenfaktor (= street factor)
Risk = Risikozuschlag (= risk factor)

The necessary information is normally available by using

- hydraulic analysis to calculate the flow and therefore the possible lack of supply
- GIS analysis by using the ALK (= official field book) to evaluate a street factor and a risk factor
- age and material to calculate a failure probability
- CCP-values to get information about condition of coating

An example of an urban gas net with CCP is pictured in Figure 5.

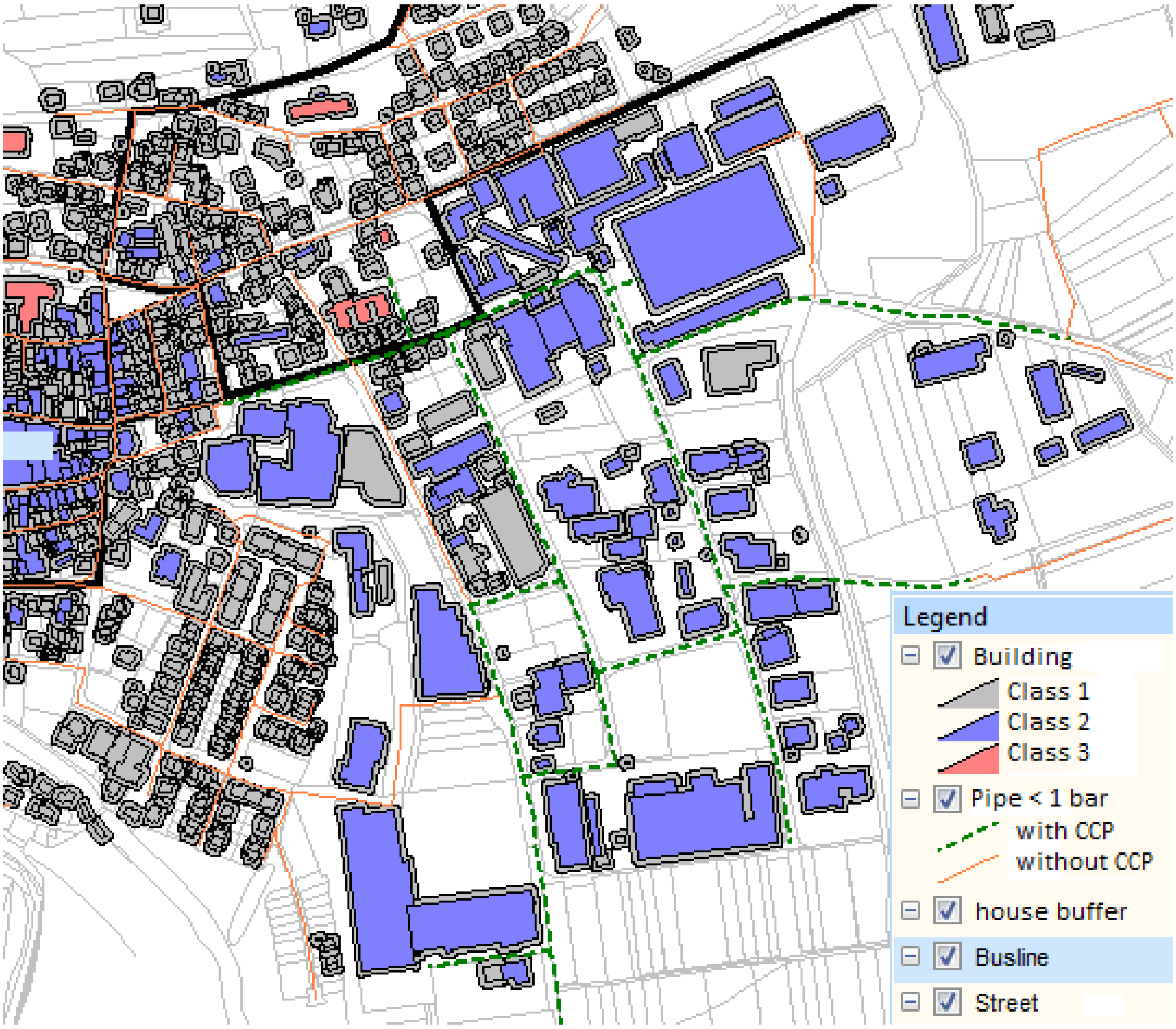

Figure 4: urban gas net with CCP

For the network a risk oriented evaluation was elaborated by using the existing information of the condition and the importance of pipes. According to the risk an optimal maintenance strategy was defined (Figure 5).

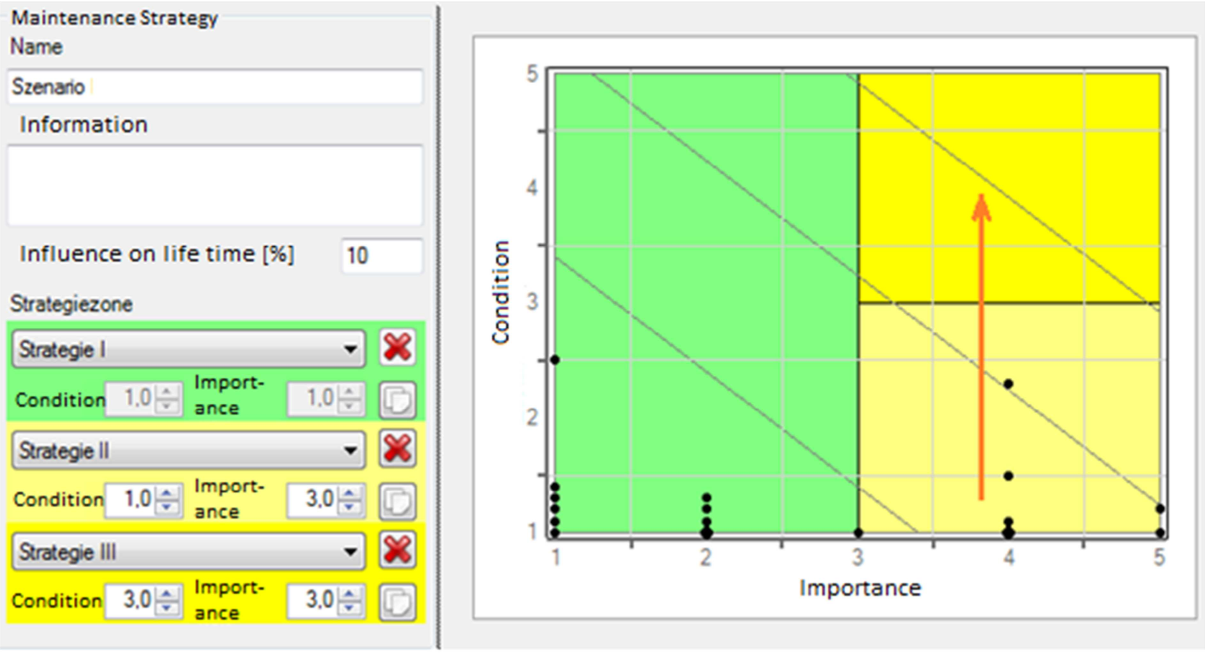

Figure 5: urban gas net with CCP and risk oriented evaluation

With the presented methods the definition of a time dependency of the change in condition is possible with a rough estimation of the age, with an adaptation of an aging function using a failure statistic or with condition values out of CCP. For the practical use asset management software (e.g. PiReM [7]) is a great support. With the available results a strategic rehabilitation rate and a necessary investment budget can be planned. A priority ranking for the mid-term rehabilitation can be derived from the strategic approach.

Conclusion

The high quality of the infrastructure is necessary for an industrial country like Germany. For keeping the grown network also in the future in a good quality the definition of the actual condition as well as a prognosis for the rehabilitation rate for the future is necessary. By using CCP-values a precise assessment of the coating of metallic pipes is possible. This information added to the existing methods (age, failure statistic) for a condition oriented prognosis will improve the plausibility of the prognoses.

Literature

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